AUTOMATIC TIP PROCESSING OF OPTICAL FIBER PREFORM

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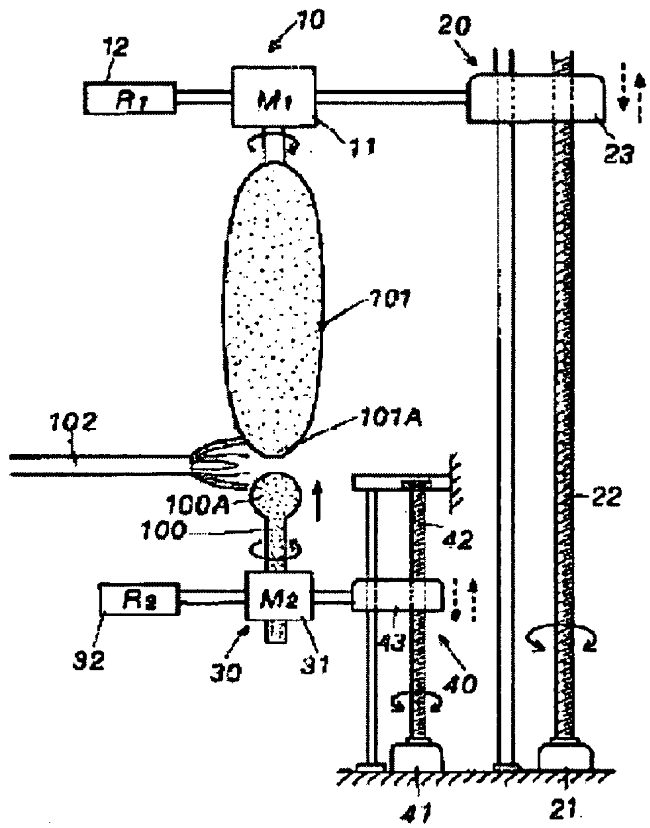
Abstract of **JP10330130**

PROBLEM TO BE SOLVED: To efficiently process the lower tip of a preform into a good spindle form by fusing a lower part of an optical fiber preform to an upper part of a dummy sphere, pulling the fused material, forming a spindle part in the fused part, then mechanically rotating both or either one thereof so as to produce a difference in extent of rotation in the preform and the sphere and simultaneously pulling a part between both parts. SOLUTION: A dummy sphere 100 is pulled upward and brought near to a lower part of an optical fiber preform 101 under rotating of the same extent of rotation of both, heated and softened with a burner 102. After both are brought into contact, the lifting of the sphere 100 is stopped while maintaining the rotation of the sphere 100 constant and then slowly lowered to pull a part between both and form a spindle part in the tip 101A of the lower part of the preform 101. The torque of the sphere 100 is suppressed for the torque of the preform 101 to apply a force in the prescribed direction of reverse rotation to the sphere 100 to form a twisted part between the tip side of the lower part of the preform 101 and the tip side of the upper part of the sphere 100, which is then lowered to twist off the dummy sphere 100 in the constricted part below the spindle part.



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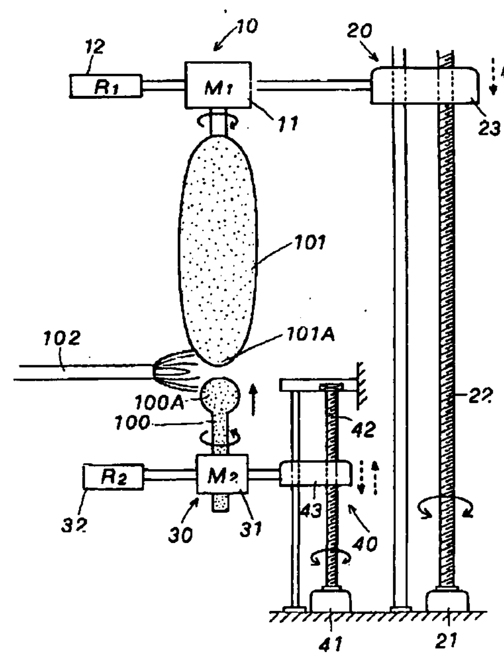
(54)【発明の名称】　光ファイバ母材の自動先端加工方法

(57)【要約】
【課題】　常に良好な先端加工を実現でき、しかも効率的に行うことができる。
【解決手段】　紡錘部が形成された光ファイバ母材101とダミー球体100とに回転差を発生するように回転させるとともに、光ファイバ母材101側とダミー球体100との間を引張させ、ダミー球体を自動的にねじ切って紡錘部を自動的に形成する。



【特許請求の範囲】

【請求項1】　光ファイバ母材（101）の下部とダミー球体（100）上部とを溶着させた後に引張して溶着部分に紡錘部を形成し、光ファイバ母材（101）から前記ダミー球体（100）をねじ切って光ファイバ母材（101）の下部先端を紡錘形に加工する光ファイバ母材の先端加工方法であって、

前記光ファイバ母材（101）と前記ダミー球体（100）とに回転量の差を生じるように双方若しくはいずれか一方を機械的に回転させるとともにこれらの間を機械的に引張させることにより、前記ダミー球体（100）を自動的にねじ切ることを特徴とする光ファイバ母材の自動先端加工方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】この発明は、光ファイバの製造に使用する光ファイバ母材の製造方法に係り、特に光ファイバ母材の下部先端を紡錘形に加工する光ファイバ母材の自動先端加工方法に関するものである。

【0002】

【従来の技術】例えば、光ファイバの製造方法の一つとして知られているVAD法では、種棒（石英棒）にスートを堆積させてスートプリフォームを形成するスート合成工程と、このスートプリフォームを高温で加熱・焼結させて透明ガラス母材（以下光ファイバ母材とよぶ）を形成する脱水・焼結工程と、必要に応じて同様のスート合成工程及び脱水・焼結工程とを繰り返しおこなう工程と、最後に線引き工程等とを経て光ファイバが製造される。

【0003】このうち線引きを行う場合には、これに先立って光ファイバ母材の下部先端を紡錘形状に加工させている。そこで、この紡錘部の加工形成方法としては、様々な方法があるが、例えば次のものが知られている。

①先ず図3に示すように、上部先端100Aがほぼ球形を有する石英棒等（光ファイバ母材と同様の材質）100（以下ダミー球体と呼ぶ）を用意し、

②これと光ファイバ母材101とをバーナ102などで同時に加熱させて軟化するとともにこれらの先端を一体に接合する。

③その後、図4に示すように、ダミー球体100を下方に引張することにより、光ファイバ母材101の下部101Aを紡錘形に加工し、

④最後にダミー球体101をねじ切って紡錘部が形成される。

【0004】

【発明が解決しようとする課題】ところが、このような一連の紡錘部の加工・形成作業は、通常、作業者が勘と経験により、手作業によって行っているので、作業能率が悪いばかりか良好な品質のものが常に得られるという訳にはいかず、個々のものに品質的なばらつきが多いなど、不都合を生じている。

【0005】そこで、この発明は、上記した事情に鑑み、常に良好な先端加工を実現でき、しかも効率的に行うことができる光ファイバ母材の自動先端加工方法を提供することを目的とするものである。

【0006】

【課題を解決するための手段】即ち、この請求項1に記載の発明は、光ファイバ母材の下部とダミー球体上部とを溶着させた後に引張して溶着部分に紡錘部を形成し、光ファイバ母材から前記ダミー球体をねじ切って光ファイバ母材の下部先端を紡錘形に加工する光ファイバ母材の先端加工方法であって、前記光ファイバ母材と前記ダミー球体とに回転量の差を生じるように双方若しくはいずれか一方を機械的に回転させるとともにこれらの間を機械的に引張させることにより、前記ダミー球体を自動的にねじ切るものである。

【0007】

【発明の実施の形態】以下、この発明の好適な一実施例について添付図面を参照しながら説明する。図1はこの発明の実施例に係る光ファイバ母材の自動先端加工方法に使用する自動先端加工装置を示すものであり、ここでは説明を分かりやすくするため、先ずこの自動先端加工装置から説明する。なお、ここで従来の技術と同一部材には同一符号を付して重複説明を避ける。

【0008】この実施例の自動先端加工装置には、従来からあるチャック機構10及び昇降機構20の他に、ダミー球体100を把持するとともに回転させる補助チャック機構30と、この補助チャック機構30を上下にスライドする補助昇降機構40とを備えている。なおこれら補助チャック機構30及び補助昇降機構40は制御部50によってその作動が制御されている。

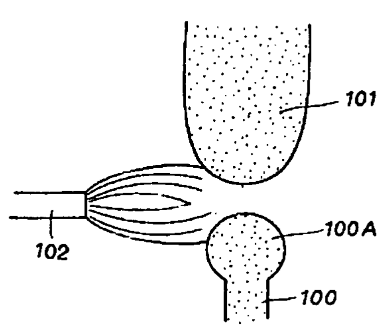
【0009】なお、チャック機構10には、自転モータ（M_1）11の他に、特に第1ロータリエンコーダ（R_1）12も備えており、昇降機構20には、昇降モータ21と、これによって回転するボールネジ22と、このボールネジ22に噛合するスライダ23とを備えている。

【0010】補助チャック機構30には、ダミー球体100を回転させる補助自転モータ（M_2）31と、ダミー球体100の回転量を検出する第2ロータリエンコーダ（R_2）32とを設けている。補助昇降機構40には、昇降機構10と同様に、補助昇降モータ41、これによって回転するボールネジ42及びこのボールネジ42に噛合するスライダ43を設けている。

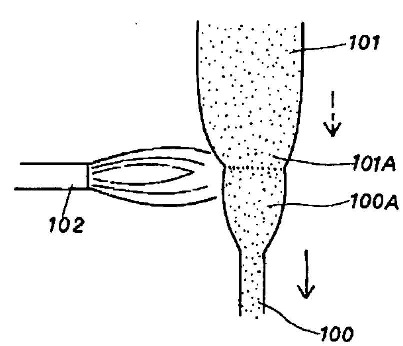
【0011】制御部50は、図2に示すように、入力が第1、第2のロータリエンコーダ112、32の出力に接続されており、これらから出力される回転信号を入力する。また、この制御部3は、出力が自転モータ11及び補助自転モータ31に接続されているとともに、昇降モータ21及び補助昇降モータ41に接続されている。

【００１２】次に、この発明にかかる光ファイバ母材の自動先端加工方法について、先の自動先端加工装置を用いて説明する。
①先ず、所定の高さ位置にある補助チャック機構３０にダミー球体１００を把持させたならば、制御部５０によって補助昇降機構４０を作動させてダミー球体１００を上方に引き上げていく。
②また、これと同時に、制御部５０により補助チャック機構３０を作動させ、初めに光ファイバ母材１０１（チャック機構１０によって回転する）の回転量と同一の回転量でダミー球体１００を回転させる。
【００１３】③このようにして、光ファイバ母材１０１の下部にダミー球体１００を下から近づけながら、これら双方をバーナ１０２によって加熱・軟化させていく。
④これによって、双方が接触したならば、ダミー球体１００は回転を一定に維持したまま、制御部５０からの制御信号によって補助上昇機構４０の作動を直ちに停止する。
【００１４】⑤その後もダミー球体１００の回転を維持したまま、制御部５０からの制御信号により補助昇降機構４０を逆転作動させ、スライダ４３とともに補助チャック機構３０を徐々に降下させて光ファイバ母材１０１の下部とダミー球体１００との間を引張させていく。これによって、光ファイバ母材１０１の下部先端１０１Ａには紡錘部が形成される。
【００１５】⑥次に、制御部５０からの制御信号によって補助自転モータ３１の回転力をセーブしていき、光ファイバ母材１０１の回転力に対してダミー球体１００の回転力を大幅に抑え、その後モータ３１によりダミー球体１００に対してある一定の逆転方向の力を加えると、光ファイバ母材１０１の下部先端側とダミー球体１００の上部先端側との間には捩じれ部分が形成される。それは第１ロータリエンコーダ１２と第２ロータリエンコーダ３２との回転量の差が、あるしきい値をこえた時に先端部のガラスが十分に軟化したことが自動的に検出される。そのときに、補助昇降機構４０を再始動してスライダ４３とともにチャック機構３０を降下させると、光ファイバ母材１０１の下部先端側の紡錘部より下の括れ部分からダミー球体１００がねじ切られて分離する。
【００１６】
【発明の効果】以上、説明してきたように、この発明によれば、紡錘部が形成された光ファイバ母材とダミー球体とに回転差を発生するように機械的に回転させることにより、接続部のガラス先端の軟化程度を常時検出することができ、それとともに、光ファイバ母材側とダミー球体との間を機械的に引張させ、ダミー球体をねじ切って紡錘部を形成するようにしたから、回転力と引張力との２種の力の制御により、常に良好な紡錘部が加工・形成可能となる。
【００１７】しかも、この発明によれば、適宜の機構を用いて自動的に紡錘部の加工・形成及びダミー球体の切断・分離を行うことにより、光ファイバ母材の先端部の加工作業の完全自動化が実現可能となるから、従来の手作業による場合に比べて飛躍的に作業時間の短縮化を図ることができる。
【図面の簡単な説明】
【図１】この発明にかかる光ファイバ母材の先端加工装置を示す概略構成図。
【図２】同装置の電気的接続状態を示すブロック図。
【図３】従来の先端加工方法を示す説明図。
【図４】同説明図。
【符号の説明】
１０　チャック機構
２０　昇降機構
３０　補助チャック機構
４０　補助昇降機構
５０　制御部
１００　ダミー球体
１０１　光ファイバ母材

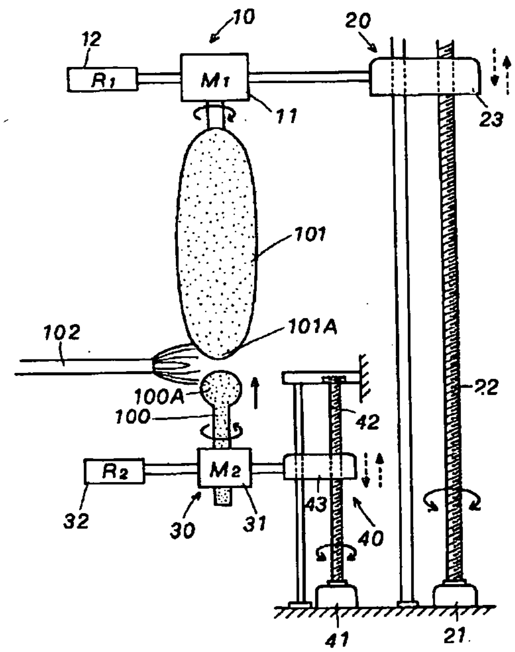
【図３】



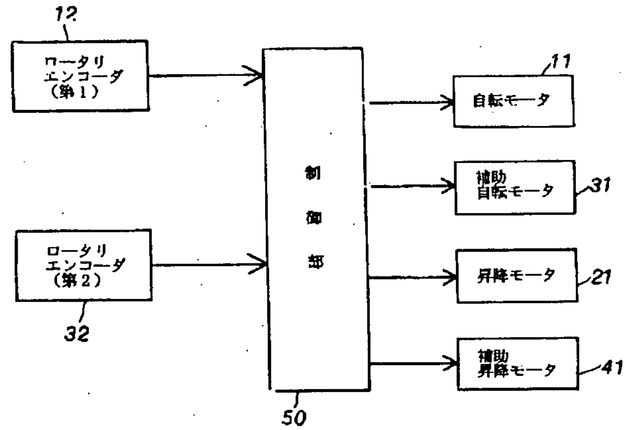
【図４】



【図1】


10
12
R1
M1
11
20
23
101
101A
102
100A
100
42
22
R2
M2
32
30
31
43
40
41
21

【図2】


12
ロータリ
エンコーダ
（第1）
ロータリ
エンコーダ
（第2）
32
制
御
部
50
11
自転モータ
補助
自転モータ
31
昇降モータ
21
補助
昇降モータ
41

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(54) **Method for making optical fiber preforms.**

(57) A plurality of elongated refractory bodies are laminated together by placing the bodies in close adjacency, exposing the adjacent bodies to a plasma torch heat source, and moving the bodies longitudinal past the torch at a nonzero average rate which includes a reciprocating (e.g.,oscillatory) component to longitudinally spread the zone of heating. Where the bodies are a rod to be laminated within a hollow tube, it is advantageous to reduce the air pressure between the rod and tube, thereby eliminating potential contaminants and, at the same time, biasing the tube to collapse against the rod. This method is particularly useful in laminating overcladding tubes to core rods to form optical fiber preforms.

EP 0 656 325 A1

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Field of the Invention

This invention relates to the fabrication of laminated refractory bodies such as, for example, optical fiber preforms.

Background of the Invention

While potentially useful in a wide variety of applications, the present invention evolved in the field of optical fiber fabrication. Optical fibers are thin strands of glass capable of transmitting an optical signal containing a large amount of information over long distances with very low loss. Optical fibers are typically manufactured by constructing an optical fiber preform of appropriate composition and drawing fiber from the preform.

A typical preform is in the form of a concentric glass rod having a length of about one meter and an outer diameter of 20-200 mm. The inner core of the rod is a high purity, low loss glass such as germanium silicate glass having a diameter of about 1-5 mm. The concentric outer cylinder, referred to as cladding, is a layer of glass with a lower index of refraction than the inner core.

In conventional manufacture of an optical fiber preform, the core is manufactured as a solid doped silica glass rod within the cladding. An outer jacket of silicate glass, referred to as the overcladding, is then added around the rod in order to provide the desired geometry for fiber draw. Specifically, the rod is placed within the overcladding tube, and the rod and overcladding are laminated to form a fiber optic preform by heating the assembly with an oxyhydrogen torch.

A difficulty with this process is that the lamination introduces in the outer periphery of the overcladding OH impurities which can be deleterious to a drawn fiber. As a consequence it is typically necessary to etch away the outer 0.5 mm of the preform with a plasma torch to eliminate the surface contaminated by the oxyhydrogen torch. Accordingly, there is a need for an improved method and apparatus for laminating overcladding and core rod in fiber optic preforms.

Summary of the Invention

A plurality of elongated refractory bodies are laminated together by placing the bodies in close adjacency, exposing the adjacent bodies to a plasma torch heat source, and moving the bodies longitudinal past the torch at a nonzero average rate which includes a reciprocating (e.g., oscillatory) component to longitudinally spread the zone of heating. Where the bodies are a rod to be laminated within a hollow tube, it is advantageous to reduce the air pressure between the rod and tube, thereby eliminating potential contaminants and, at the same time, biasing the tube to collapse against the rod. This method is particularly useful in laminating overcladding tubes to core rods to form optical fiber preforms.

Brief Description of the Drawings

In the drawings:

FIG. 1 is a block diagram illustrating a method for laminating elongated refactory bodies;

FIG. 2 is a schematic view of preferred apparatus for practicing the method of FIG. 1 in the lamination of optical fiber preforms; and

FIG. 3 is a detailed cross section of the end mounting portion of the apparatus of FIG. 2.

Detailed Description

Referring to the drawings, FIG. 1 is a flow diagram showing the process steps used to laminate a pair of elongated refractory bodies. The first step shown in block A is to put the two bodies in close adjacency. When the two bodies are a rod to be laminated within a hollow tube, the rod can be inserted within the tube.

The next step shown in block B of FIG. 1 is to provide a force biasing the adjacent bodies toward one another. In the rod/tube example, this can be accomplished by partially evacuating the tube so that there is ambient pressure on the tube pushing radially inward. Where one of the bodies is an outer tube, the biasing force can arise as a consequence of heating the tube to its softening temperature. The tendency of the softened material to minimize surface tension will shrink the periphery of the softened region.

The third step shown in block C is to expose the assembly to a plasma torch and, at the same time, to move the assembly and the torch relative to one another in such a fashion that: 1) the assembly and the torch have a non-zero average longitudinal speed, and 2) the assembly and the torch have a reciprocating motion superimposed on the overall longitudinal motion for extending the longitudinal region heated by the torch. Thus as the torch moves longitudinally along the assembly it also moves back and forth in a shorter amplitude to extend the region of heating. In the case of a tube/rod assembly, the tube preferably rotates so that all sides of the longitudinal region are heated. Advantageously the heating is commenced at the end of the tube remote from the vacuum pump.

The effect of this process is to heat to a softened state the longitudinal portion of the assembly within the amplitude of the reciprocal motion. In the tube/rod example, the pressure differential collapses the heat softened tube against the rod within thereby laminating the two bodies. The lamination process preferably starts at the remote end of the assembly and progresses to the end connected to the vacuum pump.

It should be understood that an overpressure ex-

terior to the tube could be substituted for evacuation and that a similar process omitting the evacuation step could be used in laminating elongated refractory bodies of different shape, e.g. laminating two strips. Moreover if a second hollow tube is substituted for a solid rod, the center of the interior tube could be pressurized rather than evacuating the exterior tube.

FIG. 2 schematically illustrates apparatus useful in practicing the method of FIG. 1 wherein an elongated assembly 20, such as a cladding tube, core rod assembly, is shown mounted on a controllable speed lathe 21. The apparatus is similar to that described in United States Patent No. 5,221,306 which is incorporated herein by reference. Preferably the lathe is oriented vertically so that the supported ends will not be subjected to substantial torque and the assembly 20 will not sag upon heating. The lateral surface of assembly 20 is exposed to the plasma fireball 12 of a plasma torch 10 such as that described in detail in United States Patent No. 5,000,771, which is incorporated herein by reference.

The plasma torch 10 is mounted on a three axis positioning stage 30 based on the same bed (not shown) as lathe 21 so that the torch position can be precisely controlled during operation. A computer (not shown) is provided to coordinate and control the rotation of body 20 via lathe 21 and the movement of the torch 10 via positioning stage 30. The computer controls the rotational speed of the body 20 about the Z-axis and the speed of the torch 10 along the Z-axis.

In the lamination of preforms, lathe 21 is preferably a glass lathe having simultaneously rotating chucks at both ends of body 20, such as a Litton Glass Lathe marketed by Litton Engineering Co. Step motors (not shown) are provided to drive the three axes of the positioning stage 30 controlling the location and traverse speed of torch 10.

The bottom chuck is preferably modified as shown in FIG. 3 so that the interior of cladding tube 20A below rod 20B can be partially evacuated. In essence, a reduced diameter portion of the cladding tube, termed the "handle" 20C, extends through a central opening in the chuck 31 and tailstock 32 so that the handle rests on and seals with a gasket 33. A concentric channel extends via a rotary seal 34 to the open center of the gasket 33, thereby placing the interior of tube 20A in communication with a vacuum pump (not shown). In exemplary operation, core rod 20B is inserted in a cladding tube 20A and mounted onto the apparatus of FIG. 3. The vacuum pump is activated to pump down the pressure in the tube to 25 in. of water. The tube is rotated at 30-35 rpm, and the torch is positioned at the top of the tube about 5-10 mm from the tube. The torch is moved longitudinally down the tube at 2-5 cm/min. with a superimposed reciprocal motion having frequency of 0.5-5 cps (preferably 1 cps) and an amplitude of 5-10 cm in the longitudinal direction.

The result of this process is that the cladding collapses onto the inner rod as the torch moves down the tube. The advantages of the process over the prior oxyhydrogen torch process are threefold: 1) the plasma torch does not introduce impurities into the cladding; 2) the longitudinal temperature profile is now subject to control by control by frequency and amplitude of torch oscillations; and 3) the lamination of tube or rod using the plasma torch is about twice as fast as an oxyhydrogen torch.

Claims

1. A method for laminating together a plurality of elongated bodies of refractory material comprising the steps of:

   placing said plurality of bodies adjacent one another;

   applying force for biasing said bodies together; and

   exposing said bodies to a plasma torch heat source moving longitudinally in relation to said bodies at a non-zero average rate which includes a reciprocating component of longitudinal motion.

2. A method of claim 1 wherein said plurality of elongated bodies comprises an outer hollow tube and a body disposed within said tube.

3. The method of claim 2 wherein said force for biasing said bodies together is pressure for forcing said outer tube radially inward.

4. The method of claim 1 wherein:

   said plurality of bodies comprise a hollow tube and a rod; and

   said bodies are placed adjacent one another by placing said rod within said tube.

5. The method of claim 4 wherein said force for biasing said bodies together is applied by at least partially evacuating the interior of said hollow tube.

6. The method of claim 4 wherein said hollow tube and said rod comprise silica glass.

7. An optical fiber preform made by the method of claim 4.

8. An optical fiber preform made by the method of claim 5.

9. An optical fiber preform made by the method of claim 6.

10. The method of claim 5 further comprising the pre-

liminary steps of:

forming said rod of glass including a central region of composition for the core region of an optical fiber; and

forming said hollow tube of glass of composition for the cladding region of an optical fiber.

FIG. 1

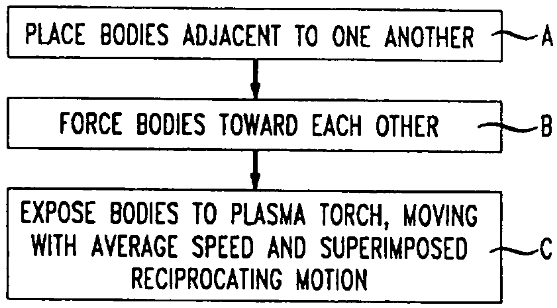

PLACE BODIES ADJACENT TO ONE ANOTHER
A
FORCE BODIES TOWARD EACH OTHER
B
EXPOSE BODIES TO PLASMA TORCH, MOVING WITH AVERAGE SPEED AND SUPERIMPOSED RECIPROCATING MOTION
C

FIG. 3

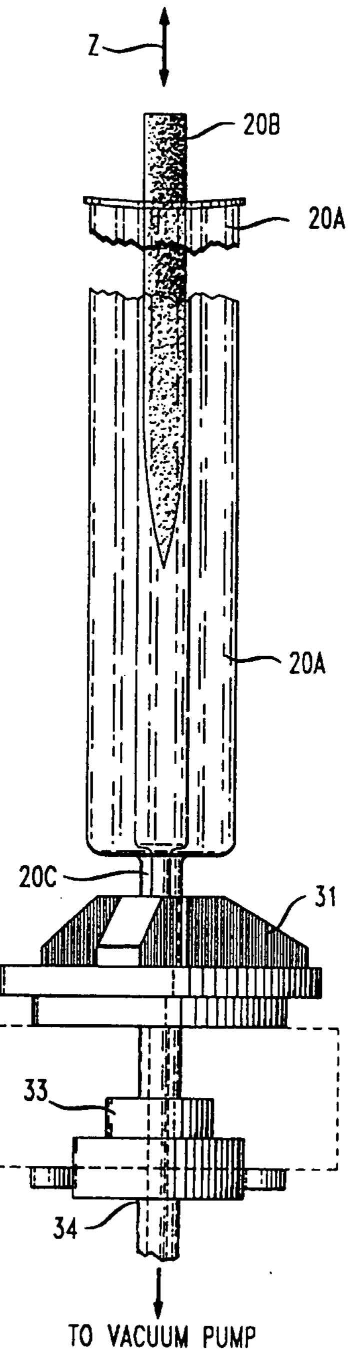
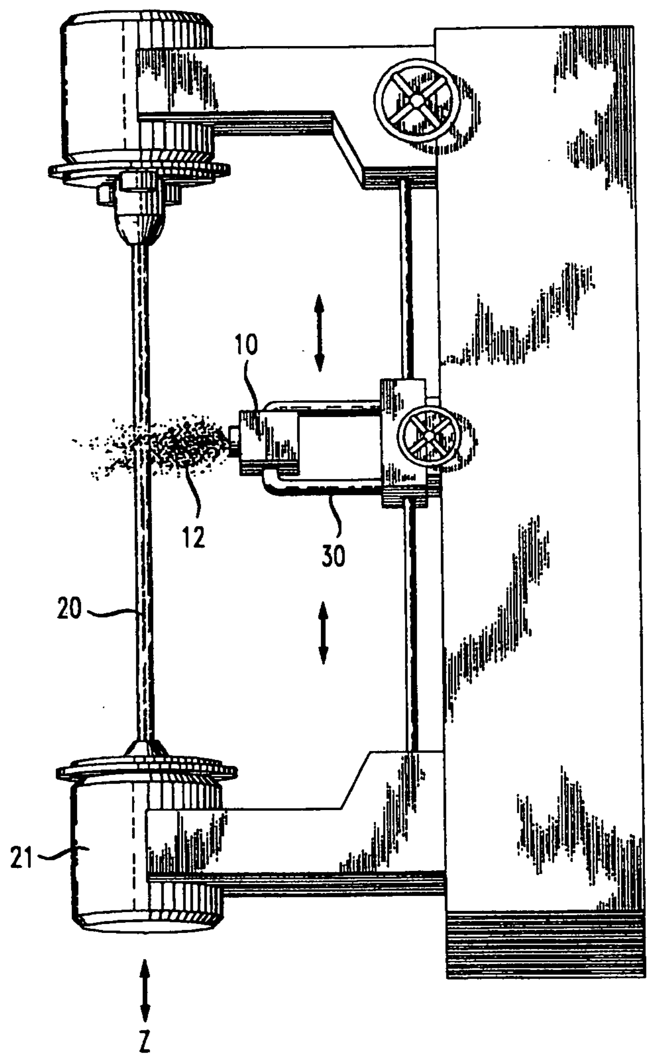

Z
20B
20A
20A
20C
31
32
33
34
TO VACUUM PUMP

FIG. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 8471

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP-A-0 244 135 (AT&T CO.) * claims 1,3; figures 1,9,10 * ---	1-10	C03B37/012 C03B23/207
Y	EP-A-0 171 103 (N.V.PHILIPS' GLOEILAMPENFABRIEKEN) * claims 1,7,9-15; figure 2 * ---	1-10	
Y	EP-A-0 309 027 (PHILIPS PATENTVERWALTUNG GMBH) * example 3 * ---	1,2,4,6,7,9	
Y	XIII ECOC 87, Technical Digest Volume III, pages 63-66; paper by A.H.E.Breuls et al. entitled, "Plasma-collpasing: a new alternative for high- rate collapsing of fibre preforms". * figure 3 * ---	1-10	
A	EP-A-0 530 917 (N.V.PHILIPS' GLOEILAMPENFABRIEKEN) ---	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	DE-A-37 20 029 (PHILIPS PATENTVERWALTUNG GMBH) ---	1	C03B
D,A	EP-A-0 439 918 (AT&T CO.) ---		
D,A	EP-A-0 484 035 (AT&T CO.) -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 February 1995	Stroud, J

CATEGORY OF CITED DOCUMENTS

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